

CHAPTER 4 - CONCEPTUAL STUDIES

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CHAPTER 4 - CONCEPTUAL STUDIES

4.1 GENERAL

The formal project development process begins with a conceptual studies phase. The conceptual studies phase identifies and evaluates alternative courses of action (i.e., engineering concepts) to address the highway's transportation needs and deficiencies. This phase advances a project listed in the multi-year program to a point where it is sufficiently described, defined, and located to allow the actual design phase to begin. Conceptual studies are closely related to the environmental process outlined in Chapter 3. The environmental reports normally summarize the engineering results of the conceptual studies.

The overall objectives of the conceptual studies are as follows:

- To fully identify and quantify a highway's transportation needs and deficiencies.
- To develop a general course of corrective action.
- To identify and evaluate with engineering analyses the feasible and reasonable solutions (alternatives) to these needs and deficiencies.

A preferred alternative is selected after the options have been jointly evaluated in the environmental phase. Assuming the preferred solution involves some form of highway upgrading, the conceptual study phase concludes with the selection of a preferred alternative with the scope of work defined by a category of improvement, geographical corridor, and preliminary highway design standards. The formal identification of the preferred alternative occurs in the final approved environmental document, and this constitutes *location approval*.

4.2 GUIDANCE AND REFERENCES

The regulations, policies, guides, and references that provide the background for implementing conceptual studies are listed in Chapter 1, Section 1.2.

For additional references on specific subjects, refer to the guidance and reference section in the appropriate chapters of this manual. The listings are not all inclusive and other documents may contain useful information in special situations.

4.3 INFORMATION GATHERING

Data collection is an integral step in the conceptual study process. The following subjects are the most common areas where comprehensive information must be gathered for highway location analysis.

A. Needs Studies (Planning Reports and Inventories). These documents provide system-wide highway information on the physical condition, current deficiencies, and future needs of routes on a system. General types of needed improvements and approximate construction cost estimates are also reported and can be used to develop a priority list of projects.

While this information is primarily used to show revenue needs or assists the priority setting/programming process, it can provide a good starting data base for conceptual studies. Usually needs studies are general in nature and must be expanded and refined into specific project data, issues, and details.

The *NPS Road Inventory and Needs Study* and *1983 Forest Highway Inventory and Improvement Study* are examples of studies conducted by FHWA's Federal Lands Highway Divisions. Federal-Aid Divisions and State transportation agencies routinely conduct other *needs* studies, which may be useful on Federal Lands Highway projects.

B. General Design Criteria. General design criteria are used to describe and evaluate highway improvement alternatives in conventional engineering terms, so that a highway's physical, structural, safety, and operational characteristics can be readily understood. While many elements of design (e.g., stopping sight distances, grades, horizontal/vertical alignment and superelevations, etc., as described in the AASHTO Green Book), must be established to conduct a detailed highway design, only a few elements are usually essential at the conceptual stage. Roadway width (lanes and shoulders), design speed, surfacing type, and corridor location are the main criteria for studying highway alternatives. Other features like side slopes, ditch widths, and clearing limits should also be identified if the total width of project disturbance appears to be a critical consideration. (See Figure 4-1.).

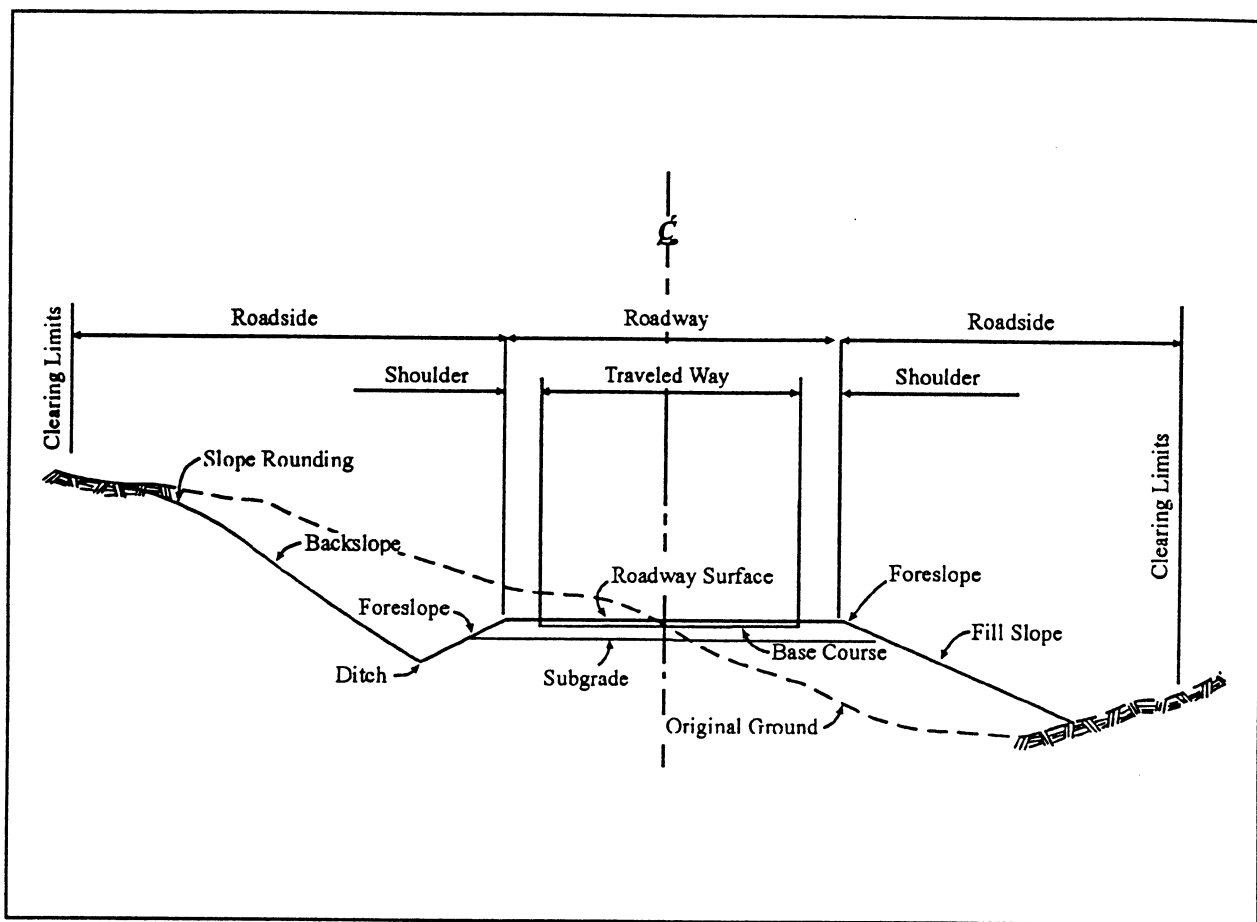


Figure 4-1
Typical Road Cross Section Elements

4.3 Information Gathering. (continued)

C. Traffic Characteristics. Traffic plays a major role in establishing the concept and design of a highway. Traffic indicates the type of service for which the improvement is being made and directly affects the geometric features of design such as widths, alignment, and grades.

General traffic data (average daily traffic and vehicle classification) is collected on almost a continuous basis by most highway departments and some land management agencies. This information can be readily obtained and provides a benchmark for traffic data in the study area. When traffic data is not present, it must be developed by special counts or by calculating the number of vehicles from related information such as National Park visitations, cubic meters of timber hauled, and recreational visitor days.

The AASHTO Green Book provides an excellent description of traffic characteristics, such as volume, directional distribution, composition of traffic projections, and speeds. While much of this information has a more direct bearing on design details, conceptual studies and associated alternative analyses are also dependent on overall traffic data. Sometimes traffic data such as operating speeds, travel time and delay, and occupancy rates are needed to address a special issue. If this data is unavailable, traffic studies as described in ITE's *Transportation and Traffic Engineering Handbook* should be conducted to provide such information.

D. Accident Data. Vehicular accident data can provide excellent guidance in determining a road's past problems. These statistics are usually maintained and readily available at the highway department, land management agency, and/or the law enforcement office responsible for that highway facility. When such data is not immediately available, a short term avoidance study or an assessment of accident potential should be conducted.

Figures for accident rates are currently shown in accidents per million vehicle miles traveled. Figures for fatality rates are currently shown in fatalities per one hundred million vehicle miles. FHWA plans to keep this figure for at least several more years, but will supplement it with fatalities per one hundred million vehicle kilometers beginning with the 1994 Highway Statistics Report. Chapter 8 describes in detail how accident rates fit into the safety analyses of highways.

E. Environmental Considerations. A highway has wide-ranging effects beyond that of providing traffic service to its users. It is essential that the highway be considered as an element of the total environment. The highway can and should be located and designed to complement its environment and serve as a catalyst to environmental improvement.

Conceptual studies are conducted concurrently with the environmental process and each has a major effect on the other. As outlined in Chapter 3, close coordination is important to ensure the range of improvement alternatives is established in recognition of overall environmental factors. This allows for an orderly, complete evaluation when determining the preferred improvement alternative. Also, design of the preferred alternative must reflect the mitigation commitments identified in the environmental phase.

F. Reconnaissance Study. The reconnaissance study or survey is a traditional term given to the engineering process now called *conceptual studies*. Originally, it was associated more with the investigation and evaluation of road corridors on new alignment. In contemporary terms, the field inspections and engineering involved with identifying and quantifying a highway's deficiencies and needs, developing a course of action with improvement alternatives, and conducting engineering analyses that result in a preferred alternative are collectively called a *reconnaissance study*. Project planning study, route study, feasibility study, and preliminary engineering study are all terms used by different agencies and offices to mean some form of reconnaissance activity that falls within the conceptual study phase.

4.3 Information Gathering. (continued)

G. Aerial Photography and Mapping. Aerial photography and mapping (described in Chapter 5) generally provide very valuable and essential data in the study and illustration of highways, roadside features, and proposed highway improvements. Detail maps and sometimes mosaic photo composites developed specifically for the highway in the study area are needed in the conceptual study stages when improvements include new corridors or substantial widening and/or curve flattening. Many times USGS quadrangle maps or aerial photographs from other agencies can be obtained to suffice or assist in the conceptual studies, especially when more minor improvements are being investigated.

Oblique and terrestrial photography can be quite helpful to study proposed improvement corridors and can be enhanced by photomontage techniques to illustrate future highway improvements. Such techniques require a preliminary design (cross section, earthwork, etc.), a time consuming and labor intensive program.

H. Geotechnical Reconnaissance. Preliminary geotechnical information should be obtained early in conceptual studies by specialists in this field of engineering. This will assist in determining the cause for instability or pavement problems on the existing highway and provide information on potential problems for constructing the alternatives under consideration. Subsurface investigations in the study area may be required if existing information is inadequate and/or incomplete.

Typically, a geotechnical reconnaissance report addresses the following:

- Geology of the study area.
- Existing and/or potential unstable soil conditions.
- Location of possible sources or sites for base, surfacing, and topsoil materials.
- Estimated surfacing requirements.

More *in depth* investigations are conducted later on in the project development process as described in Chapter 6.

I. Hydraulic Information. Where water resources affect the road corridor (i.e., flood plains, erosion, drainage, water quality, etc.), hydraulic information should be obtained for the conceptual studies by specialists. This data aids in determining the cause of some road problems and, more importantly, provides guidance to determine feasibility, location, or size of hydraulic structures for the alternatives under consideration. This data is needed more to address environmental concerns and establish a datum than to resolve engineering design problems, which are addressed in the design phase. See Chapter 7 for obtaining detailed information about hydraulic data and procedures.

J. Public Involvement. Public involvement is a formal environmental process requirement as shown in Chapter 3, it does provide necessary input and benefit during conceptual studies. As outlined in Chapter 3, it is important to publicly announce the beginning of the conceptual studies phase especially for the larger scale projects. This can help in identifying the *local* perspective on what are the major highway problems and driving difficulties along the route. Once alternatives have been developed, public input can be obtained through the environmental review process for the proposed improvement alternatives and their respective scopes of work.

4.4 LOCATION ANALYSIS

The location analysis combines preliminary investigations by nearly all the transportation engineering disciplines, (such as traffic engineering, survey/mapping, geotechnical, hydraulics, structural engineering, and roadway design) into a coordinated comprehensive assessment of a highway's transportation problems and a feasibility study of possible solutions. The analyses involve evaluating diverse field data, yet the analyses are preliminary or general in nature. A higher degree of technical detail is necessary in the design phase.

The types and sequence of steps in the conceptual study process are described in the following subsections. The technical analyses are not always presented in depth, but references are given to the other chapters where the preliminary and detail design requirements are discussed.

A. Course of Action. Depending on the degree of investigation and analysis in the planning phase, a project's course of action, as it enters the conceptual study stage, could vary greatly, from a simple description of study area limits to a specific course of action, (e.g., replacement of a particular bridge, etc.). To fully develop a complete, specific course of action, the overall highway deficiencies and transportation needs must be well identified, quantified, and evaluated in the conceptual studies.

The first step is data collection. This consists principally of an inventory of the physical and operational features of the existing highway. Most of this information is available from the highway agencies (highway departments or Federal land management agencies), road monitoring reports, and planning/reconnaissance studies. One should determine and verify with field inspections the road's length, width, surfacing type, traffic control devices, and roadside features along with their current condition. In addition, the road's maintenance condition and recurrent problems are important and should be documented. Also, general traffic data and operational characteristics including seasonal variations, peak use, vehicle types, and their volume percentages should be obtained. Travel information like running speeds, congestion periods, or any irregularities should be determined. Usually the maintenance forces have many observations to offer. The amount of other road users, such as bicyclists and pedestrians, must also be established.

Do not overlook winter driving conditions including problems of removing snow and ice. Rural farming areas may also present unique problems of moving farm machinery on the highway.

The current traffic accident statistics for the route should be obtained. This must be supplemented with field identification of potential accident sites that may not be discernible from the past data.

After gathering the data, compare the existing road and its current functional classification, geometric standards, physical condition, and present travel demand with the highway agency's road standards. The Green Book's Geometric Standards are broad enough to address most types of roads if there are no other standards that apply. A listing of the road's current deficiencies, both physical and operational, and relative importance of each should be prepared to indicate where the road is substandard and not functioning properly. Exercise care when determining the major contributing factors of a defective road facility. Do not automatically assume an existing substandard road feature is the problem.

Next, the long-term needs of the highway must be determined. Usually this is based on projections of how land use activities in an area are going to change along with their associated transportation requirements. Longterm transportation needs are commonly described by a forecasted 20 year ADT and percentages of vehicle types, (e.g., trucks, buses, recreation vehicles, etc.), in the travel stream. Other factors like urbanization of the roadside and functional classification changes also directly affect future needs.

The land management agencies through their planning offices and area-wide comprehensive planning documents (e.g., NPS General Management Plan, NPS Development Concept Plans, and FS Forest and Resources Management Plans) can provide some information and assistance in determining future travel

4.4 Location Analysis. (continued)

demands on highways. Comparing the current highway facility with the geometric standards of a road that is sized to accommodate its future traffic volumes and travel conditions will usually indicate what upgrading may be necessary to address the long-range transportation needs.

To establish a course of action, one must recognize the existing road, its deficiencies and future needs, and then describe the type of improvement required to create a highway that meets objectives. Usually the objectives are to provide the highway user a facility that fulfills the following:

- Meets the convenience and safety standards for that system of highways.
- Is cost effective to build.
- Avoids or minimizes environmental impacts.
- Minimizes maintenance costs.

A typical course of action addresses the road's width, alignment, surfacing, major structures, and the general types of construction items needed to implement such improvements. The following is an example of a typical course of action.

Route 1 is to be upgraded between A and B by widening to provide two continuous traffic lanes and shoulders. The horizontal and vertical alignment will also be flattened and corrected to provide a uniform design speed. The road will be stabilized, paved, and delineated with standard traffic control devices. The bridge over Clear Creek at Kilometer 198 will be replaced. The principal items of work consist of clearing, grading, drainage, base, asphalt surfacing, signing, striping, and bridge construction.

The intent is to generally describe the type of improvements to be done, but leave flexibility so various alternatives can be considered that will accomplish, to one degree or another, the proposed course of action.

B. Alternatives. Once the course of action is established, the next step is to identify all reasonable alternatives that can implement the work. These should be practical engineering solutions to the road's problems, e.g., current deficiencies and future needs, within the overall limits of the course of action.

Initially, alternatives might cover quite a range or scale of improvements, but they should be condensed to three or four succinct alternatives for which further engineering analyses can be applied. Otherwise, the details, data, and description become too cumbersome to handle. The basic categories of alternatives to be considered on most road upgrading include the following.

1. No action. The no action alternative would only continue the routine maintenance of the facility and does not include any upgrading that would change the road's operation or extend its service life.

2. Transportation System Management (TSM). This alternative should always be considered when upgrading a road. It consists of travel controls and/or limited construction to maximize the operation and efficiency of the existing facility without major reconstruction or new construction. Sometimes these controls might include one of the following:

- Accommodating the existing traffic on other routes or with different types of vehicles.
- Posting vehicle restrictions and load limits.
- Providing an alternate, more attractive mode of transportation.

Usually, this form of TSM alternative is only marginally effective for Federal Lands Highway Programs because of the outdated, rural highway systems, and automobile dependency present in most FLHP situations.

Resurfacing, restoration, or rehabilitation (RRR) projects are TSM alternatives with limited construction efforts that can be very cost effective measures. The objective is to preserve and extend the service life of the existing highway and enhance safety without substantial costs, construction impacts, or major right-of-way takings. Generally RRR projects are not reconstructed to full geometric standards.

RRR work is undertaken to preserve and extend the service life of an existing highway and enhance highway safety. This may include placement of additional base and surface material and/or other work necessary to return an existing roadway to a condition of structural or functional adequacy. The RRR work is generally done on existing alignment. This salvages a substantial amount of the existing surfacing, but may include some upgrading of geometric features, such as minor roadway widening, flattening curves, or improving sight distances.

RRR projects are customized for individual situations and may result in exceptions to conventional standards. The improvements, whether only at spot locations or continuous, should adequately meet existing and hopefully future (10-20 year) traffic needs and conditions in a manner conducive to safety, durability, and economy of maintenance. Usually, the upgrading only addresses the most critical deficiencies of the highway so the resultant condition may still have some problem areas/ substandard features.

Any substandard design elements require approval as design exceptions as set forth in Chapter 9.

3. Reconstruction. This is an improvement alternative that rebuilds a highway essentially along the same alignment and when the retention of the pavement structure is not a primary objective.

Reconstruction work normally involves a substantial construction effort to rebuild the existing highway to at or near full geometric/safety standards.

The complete spectrum of design deficiencies and functional obsolescence of the roadway, as well as future transportation needs, should be addressed by this level of upgrading. The work normally includes activities such as widening, realignment, and replacement of bridges. While reconstruction, by nature, follows an existing road corridor, it may deviate significantly in width and alignment from the present road to obtain its full geometric standards.

4.4 Location Analysis. (continued)

4. New construction. This is an improvement alternative to build a road and/or bridge on completely new alignment, or substantially upgrade a highway facility along an existing alignment providing new access to or through an area.

Usually the highway is built on new alignment in a virgin corridor. It normally is constructed to full geometric standards to fulfill both the current as well as longterm transportation needs of the area.

a. Preliminary Design Standards. Proposed highway improvement alternatives are principally described by preliminary design standards. The design standards listed in FLHM 3-C-1 can be supplemented or substituted with approved highway design standards from owner agencies. These substitutions must be consistent with the highway program legislation, regulations, and interagency agreements discussed in Chapter 2.

While the categories of alternatives indicate the overall level of upgrading, more specific terms must be used to describe an alternative beyond the general course of action to evaluate its operational, safety, and structural characteristics. The roadway width, design speed, and surface type are the main elements of the general design criteria used to describe an alternative's preliminary design standards. Other elements (like the full typical roadway cross section, preliminary line and grade, grading/clearing limits, auxiliary lanes/tapers, and right-of-way widths) are sometimes included when the environmental analysis requires more specific information to evaluate roadside impacts.

The intent of conceptual studies is not to develop the design of the project, but to provide direction and scale of the improvement. Given this direction, the designer should develop the most cost-effective design of the preferred alternative.

Thus a good conceptual study should do the following:

- Identify, evaluate, and compare impacts of each alternative.
- Establish design flexibility.
- Define commitments to protect and preserve the environment.
- Provide long-term planning guidance.

Preliminary concept studies define the project by line and grade, right-of-way limits, construction quantities and roadway geometrics in general terms based on projected traffic volumes, terrain, and other special features. During the design phase of the project, these activities will be addressed in more specific detail. See Chapter 9.

To establish the preliminary geometric design standards of roadway width and design speed, it is necessary to know the road corridor's predominate terrain (level, rolling, and mountainous), the functional classification of the route, and the traffic volumes (current/future ADT) on the highway.

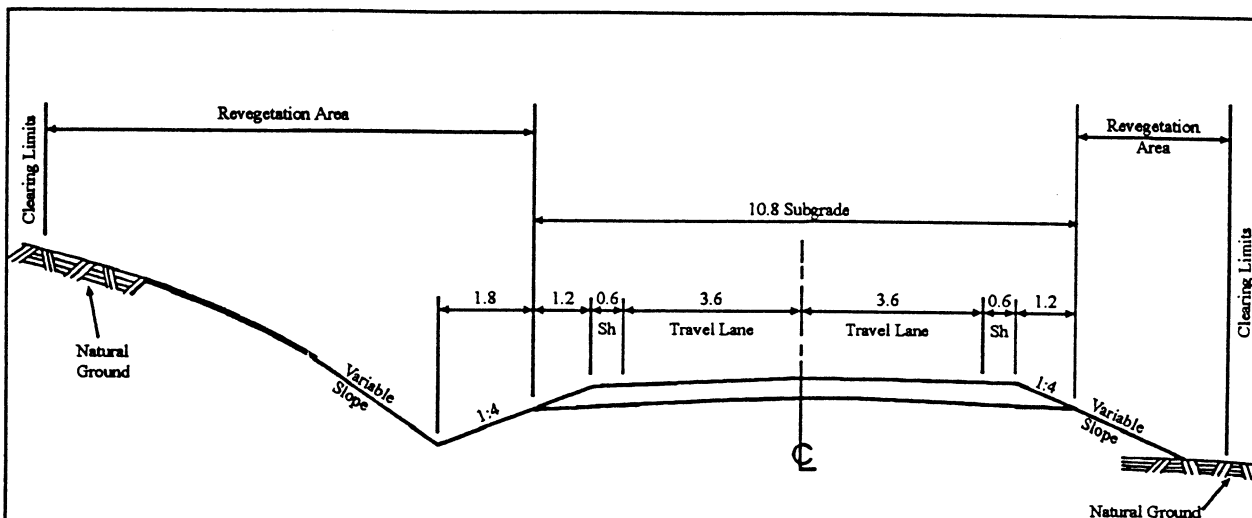
While in many cases the minimum AASHTO geometric standards will provide the most appropriate level of safety, convenience, and operational efficiency, alternatives with different standards must also be considered to address any special factors (e.g., economic, environmental, or operational, etc.) that affect the road. Gathering and evaluating diverse land use, transportation, environmental, and economic data, together with applied engineering judgment and analysis, will aid in formulating practical improvement alternatives above and/or below the minimum full standards.

4.4 Location Analysis. (continued)

The preliminary design standards used to describe the alternatives provide guidance for establishing other criteria to be used in the design process. Many of these other elements are functions of the ADT, design speed, or roadway width and are set during the design activities. The preliminary design standards, as well as the other design standards and criteria, become the final adopted project standards when the design approval is issued (see Chapter 9).

Figure 4-2 is an example of how to show and describe an alternative and its preliminary design standards. This information should also be supplemented with a map depicting the location of the alternative as discussed in the next subsection. When comparing numerous alternatives, it can also be rather effective to display them together in a conceptual setting.

4.4 Location Analysis. (continued)



ALTERNATIVE A

Note: This alternative for the reconstruction of 105 km of Flat Mountain Road by widening and adding bituminous surfacing to obtain a 8.4 meters wide roadway consisting of two 3.6 meters paved lanes and two 0.6 meters paved shoulders. Roadside features such as 1:4 foreslopes, variable ditch widths, and backlopes with minimum selective clearing are included to provide a reduces, but adequate, cross section with standard sight distances and roadside safety.

The horizontal and vertical alignment of the existing road will be adjusted by curve flattening, grade raises, and short relocations to provide a minimum 60 km/h design speed. Necessary widening will be provided with the least effect on natural features and private property. Generally, widening will be made on the roadside away from the river or other sensitive features such as wetlands.

The bridge over Deep Creek at km 20.1 is to be replaced in approximately the same location. The existing right-of-way can be used in constructing much of this alternative. Partial takings from parcels along the existing roadway totaling approximately 0.93 ha will be required for widening, improving the sight distance, and reducing the severity of curves.

The proposed improvement of FH 72 begins at km 20.8 which is the northern terminus of previous improvements, and generally follows the existing road to the vicinity of Dutch Road, about km 20.4. At this point an alignment shift is proposed 60± meters to the east of the existing road. This approximately 600-meter long relocation would avoid a congested area formed by residences and commercial property bordering the east side of the existing road and a historic mine site bordering the west side. The proposed improvement connects with the existing road at about km 20.9 and generally follows it northerly to its terminus at an intersection with US 22 (km 30.2).

Figure 4-2
Typical Presentation of an Alternative

b. Highway Corridor. When formulating improvement alternatives, it occasionally becomes apparent that a highway should be considered on new alignment in a corridor outside of the existing road. In fact, there may not even be a road connecting the termini, although this situation is not common.

New highway corridors are usually identified and evaluated separately from an alternative's preliminary design standards although they must be compatible with all the components that make up the alternatives. A highway corridor can be defined as a linear strip of ground that connects termini and has sufficient width and variable positioning on the terrain to allow a road with its preliminary design standards to be built within its borders.

Depending on length and terrain, most corridors are between 30 to 120 meters wide. Its position on the topography is tied to existing land forms and sometimes defined in relation to a survey traverse line (see Chapter 5).

Highway corridors are normally established with three general objectives in mind:

- (1) The corridor must be broad enough to allow the highway centerline to be positioned or shifted in conformance to the geometric standards and to achieve reasonable cost effectiveness.
- (2) The geographical and geophysical features should be stable and compatible with the construction, operational, and maintenance requirements of the highway.
- (3) The environmental impacts should be minimized and aesthetics maximized.

In the past, the whole process of investigating new highways and corridors has been called a location survey or reconnaissance study; now, much of the process is covered in the environmental analysis and documentation.

The basic procedures in establishing feasible highway corridors are still valid and are described in the following paragraphs.

A thorough initial investigation is essential in making effective corridor determinations. If the most feasible, serviceable, and economical corridor is not determined at this stage, no amount of engineering effort can overcome the inherent deficiencies that will exist. When presenting corridor evaluations, it is imperative that the same basic data and methods of investigation be used for each corridor studied.

Most corridor reconnaissance work is done using photogrammetric or other topographic maps supplemented with field data. On occasion, ground reconnaissance surveys are made as a substitute for or supplement to the topographic mapping.

Before beginning the study, the reconnaissance engineer should review all available maps and photographs to determine what additional data and mapping are needed for conducting the study.

The following information will usually be pertinent to corridor studies:

- Land use, population, and density.
- Geophysical and geological formations.
- Potential of the area for future industrial, residential, farm, or recreational development (land use changes).

4.4 Location Analysis. (continued)

- Frequency, condition, and type of existing roads and highways serving the area.
- Existing utilities and facilities, planned and potential, such as transportation (other than highways), dams, power lines, gas and water lines, and recreational areas.
- Photographs of controlling features.

Photogrammetric maps, topographic maps, and aerial photographs of the area are good references and may be obtained from the following sources:

- Previous surveys and reports.
- Maps by Federal, State, county, and municipal agencies.
- Quadrangle maps by U.S. Geological Survey (USGS), U.S. Coast and Geodetic Survey, and Civil Aeronautics Board.
- Hydrographic surveys of rivers and river and harbor surveys by the USACE.
- Tideland maps by the State land department.
- Surveys by the Bureau of Reclamation, NPS, and BIA.
- Highway right-of-way maps by FHWA, State, and county agencies.
- Township maps by the BLM.
- Maps by Forest Service (transportation maps, firemen's maps, topographic maps, etc.).
- Stereophotographs from private sources and government agencies, particularly the USGS and the Department of Agriculture.
- Geological reports and bulletins.
- Railway maps and profiles.
- Maps made by the State planning divisions (county maps showing county road systems and roadside culture and city maps which include the immediate surrounding area).

(1) Mapping Requirements. The type and scale of mapping required for the advance planning study are dictated by the terrain and land use intensity of the route corridor area and the level of preliminary design analysis to be conducted. The maps must be complete, current, and give full details of topography and physical features.

Mosaic reproductions or photographic prints may be used to show routes or portions of routes. The route plan should be made to the same scale as the mosaic copies. If oblique photographs are used, they should show the route in contrasting lines and should be delineated legibly. The date of photography should appear on the maps.

4.4 Location Analysis. (continued)

Mapping for areas of moderate to intensive land use should be to a scale of 1:1000 or 1:2000 with a 2 or 4 meter contour interval. In areas of limited or homogeneous land use and in mountainous or heavily timbered areas, a map scale of 1:5000 with 4 meter contour intervals will suffice. If only broad reconnaissance is to be done, existing USGS quadrangle maps with their 1:24 000 scale may also be adequate.

The photogrammetric mapping may be used where feasible and where its use is cost effective. Further mapping discussions are contained in Chapter 5.

(2) Photographs. Ground photographs or oblique aerial photographs should be taken of controlling elements in the field to supplement the mapping. These can be used in analysis, report illustration, and for exhibits in the public involvement process.

(3) Corridor Selection. Specific procedures should be followed in the selection of route corridors for comparative evaluation. Common points of termini for all routes to be studied should be identified in addition to any constraints that may limit alignment, grade, and route location.

Typical constraints include the following:

- Limitations imposed by design standards such as maximum allowable grades and curvature.
- Physiographic controls, such as land form and watercourse gradients, shorelines, property or jurisdictional boundaries, preemption of lands for other (usually higher) use, and the avoidance of known problem areas such as unstable or highly erosive land forms.
- Economic controls, including encroachment on high cost lands or improvements, and alternatives involving features of excessively high construction cost.
- Mandated points of contact. For example, intersection with a limited access facility where the access point is predetermined, or access to a major point of interest that has a fixed location.
- Environmental controls, some of which are mandated by law, govern the avoidance of wetlands, prime and unique farm lands, habitat for endangered species, historical and archaeological sites, and park lands.

(4) Aesthetic Elements. Weigh the aesthetic qualities of the corridors under investigation as carefully as those that contribute to traffic safety, highway efficiency, and structural adequacy. Gentle curves, easy grades, and lanes with adequate clearance between passing vehicles contribute both to pleasant and safe driving. Both horizontal and vertical alignments should be coordinated to create a total roadway alignment that complements rather than disrupts the natural land form.

Pleasing appearance can usually be achieved at little extra cost if the road is located with these aesthetic elements in mind from the start. Further, roadside development (viewpoint, fisherman stopping areas, etc.), erosion control, flattening and rounding slopes, seeding, and revegetation contribute significantly to roadway beauty and safety as well as reduce maintenance cost.

4.4 Location Analysis. (continued)

When the merits of competing locations are nearly equal, scenic quality may be a deciding factor.

To ensure aesthetics in highway design, do the following:

- Direct the highway toward worthwhile scenic features within reasonable range.
- Locate the highway so that scenic features are large (mountains, lakes, etc.) and directly ahead of the driver's line of vision.
- Make maximum use of independent horizontal and vertical alignment on divided highways to blend the roadways into the terrain and reduce harsh effects and unnecessary construction scars.
- Coordinate vertical and horizontal curvature. The best appearance is achieved when vertical and horizontal curves coincide or horizontal curvature leads vertical curvature slightly.
- Avoid short, abrupt horizontal and vertical curves, especially if the central angle is small.
- Avoid long tangents in rolling country. Roller coaster profiles are visually distressing.
- Ensure that sufficient right-of-way area can be provided at ends of tangents and on the inside of curves to permit ample clearing and to prevent erection of buildings or structures that could impair perspective or horizontal sight distance.
- Avoid unsightly obstacles by adjusting the alignment away from the obstacle before it is within the driver's view.

(5) Map and Photograph Study. Use a large scale map that shows only the major topographic features (rivers, mountains, roads, cities, and towns, etc.), to show the various alternative corridors between the termini. By studying this map, select the more representative alternatives. The most feasible alternatives to be evaluated in detail may then be chosen through a process of elimination.

Next, the locator should intensively study and analyze the collected material before going into the field. If good photographic and map coverage is available, much of the hard work of reconnaissance can be done by stereo analysis and map study. Impractical locations can logically be eliminated, freeing the locator to concentrate on the more promising alternatives during the field investigation. Further refinement or elimination of alternatives may occur following the field investigation.

(a) Map Study. Study of the topography between assigned termini will reveal *avenues* through the terrain that may be followed for a road location, and barriers that must be avoided. Ridges or watersheds are often good avenues, and where there are long regular ridges leading in the right direction, the locator is indeed fortunate. Valleys are also excellent avenues if they lead in the right direction. The most difficult locations are those that cut across the natural avenues or those that lie in confusing terrain where the ridges and streams have no continuous well-defined direction.

Each possible avenue should be examined, though some may be immediately discarded as impracticable. Each practical route should be sketched on the map using different colors or line symbols. Where the gradient might be controlling, the grade contour should be stepped out on the map with a bow divider to make sure the route grade is within acceptable limits. Points where curvature may be critical should also be checked.

4.4 Location Analysis. (continued)

(b) Stereo Analysis. A reasonably good study can be made by stereo examination of aerial photos. It is possible to check gradients using only the stereoscope and an engineer's scale. Possible lines may be sketched on the photos and compared with map locations. Stereo examination will yield information that may not be shown on a map, so if both the map and photos are available, both should be used.

A thorough map or stereo study should investigate all possible routes within a band that is 40 to 60 percent as wide as the distance between termini. If adequate photo and map coverages are not available, the locator should view the terrain from a light plane or helicopter before going into the field. Under some conditions it is desirable to have air photos of the route made for use in the reconnaissance.

The time required for the field work of reconnaissance depends on the effectiveness of the preliminary office studies, and the accessibility of the route, weather, etc., and might vary from a day to weeks. The field investigation can be made by any means available, such as by vehicle, horseback, or on foot. During this investigation, the locator observes and keeps notes on the forest cover, drainage, bridge sites, the nature and classification of the soil, rock outcrops, land use, and anything else that might affect the location.

(6) Major Considerations and Physical Controls. The termini is the major control of the route. From a strict user's standpoint, the most economical route is a straight line between the termini, both horizontal and vertical.

However, the practical economic location and the environmentally acceptable locations are based upon a compromise between construction cost, user's cost, and environmental impacts.

Physical controls affect the construction costs-bridge sites, rock areas, valley and mountain sides, built-up areas, lakes and drainages, etc.

(7) Information to be Obtained. On each corridor studied, the following information should be known:

(a) Termini. Common study termini should be used even though some routes may use portions of existing facilities that already conform to standards.

4.4 Location Analysis. (continued)

(b) Traffic Data. Assembly of data on traffic and projected roadway use requires a thorough research effort. Primary source agencies are Federal, State, and local road administration and planning agencies. In some instances it may be necessary to conduct special traffic studies as a part of the corridor study.

Research and collect all available data on the following subjects. Items 7, 8, and 9 are optional depending on specific project requirements.

1. Traffic data on existing facilities.
 - Average daily traffic.
 - Seasonal average daily traffic.
 - Peak hourly volumes.
 - Design hourly volumes.
2. Traffic trends, past and projected.
3. Classification of vehicles (percent passenger vehicles, percent trucks and buses, and percent recreation vehicles).
4. Accident data.
 - Route segments.
 - Spot high hazard locations.
5. Directional split.
6. Turning movements at major intersections.
7. Traffic desire lines.
8. Speed and delay data.
9. Conflict study data.

(c) Right-of-Way. Describe the property affected and the nature of damages, estimate of right-of-way cost, and any special right-of-way problems. If all or part of route crosses government land, identify the agency controlling the land.

4.4 Location Analysis. (continued)

(d) Geology. Give the geology of the general area. Use a geologic map if one is available.

Interpret and show the relationship of the geology to the proposed route. Include location and extent of the following features:

- Landslide areas.
- Solid rock.
- Unconsolidated material.
- Ground water and surface water conditions.
- Availability of road construction materials (type of deposits, quantity, and quality).

Make recommendations for type of materials to be used, e.g., borrow, waste sites, contractor staging areas, etc.

(e) Controlling Factors. Describe all controlling features involved in route selection, such as the following:

- Railroad crossings.
- Bridges and other structures.
- High voltage power line crossings (record elevation of low point in cable and air temperature).
- Problems involving terrain and/or access.
- Utilities and/or special services.

(f) Design. Describe range of proposed preliminary roadway design standards, especially alignment and grades, roadway sections, type and cost of structures, and other preliminary design elements being considered. Many of these are illustrated in a roadway cross section.

(g) Construction Materials. Describe all construction materials available in the area. Identify pit sites by location and pit number, if known, and give names and addresses of local construction materials' suppliers.

Depending on the detail and accuracy being required, a preliminary design line may have to be developed through the corridor to approximate and represent the alignment and construction cost parameters. The procedures for developing the line and grade projection/ information is found in Chapter 8, Section 8.4.

Cost estimates for constructing a road in the corridor are developed using quantities and unit prices for the major items such as the following:

- Clearing and grubbing per hectare.
- Unclassified roadway excavation per cubic meter.
- Minor drainage per kilometer.
- Surfacing and base per kilometer.
- Paving (type) per kilometer.
- Revegetation and landscaping per kilometer.
- Major structures per each (identify).
- Right-of-way cost estimate per hectare.
- Miscellaneous. (Include construction traffic control, guardrail, guide posts, fences, etc.).
- An estimate of the user's cost both per kilometer and from termini to termini.

(8) Corridor Study Report. Extensive corridor analyses are sometimes documented in a formal corridor study report that then can be considered a Conceptual Study Report. More frequently, though, this information is kept informal. In either case, corridor analyses are summarized in the major environmental documents, e.g., Environmental Assessment and Environmental Impact Statements. The corridor study reports not only contain the results of the corridor analyses but also summarize the preliminary design standards under consideration. In addition to the engineering information, the social, environmental, and economic features of the alternatives (separate corridors) used in the analyses are presented at least in a general fashion.

The final study report should contain the following items:

- (a) Introduction.** Describe the authority and purpose of the study.
- (b) Organization.** Identify all sources of information, maps, and data obtained for the study.
- (c) Climate, Physiography, and Geology.** Provide a description of the climate, significant geographic features, land uses, and geology of the area.
- (d) Preliminary Design Standards.** This section should include all traffic data and design criteria for the study.
- (e) Corridor Descriptions.** Provide a detailed description of each corridor studied.
- (f) Comparative Evaluation.** This section should contain a comparative evaluation of routes studied. Include a dissertation of the related SEE impacts (such as changes in land uses, displacement of residences, disruption of communities, environmental mitigation measures, construction costs, road user costs, secondary economic factors, etc.).
- (g) Benefit Cost Analysis.** An optional section that may be used to provide a benefit cost analysis for each corridor and the basis for them.
- (h) Exhibits.** Use exhibits to include route maps or aerial mosaics depicting the location of the corridors, typical roadway sections, vicinity maps, route profiles, physical characteristics outlined on reconnaissance study form, and detailed cost estimates of alternatives.

4.5 APPROVALS

At the conclusion of conceptual studies, a decision must be made identifying which alternative is going to be advanced into the design phase.

A. Conceptual Engineering Studies. Since the results of the location analysis provide the critical engineering and/or reconnaissance information, array of alternatives, and in some cases the preferred alternative to be contained in the public environmental document; these findings should be reviewed and concurred in by the appropriate Division staff who are responsible for the clearance of environmental documents. In addition, land management agencies should also review and concur in the engineering findings regardless of whether they have been documented by informal analyses or in complete, formal conceptual (corridor) study reports. This will ensure the environmental process is evaluating alternatives that the agency is comfortable with. Concurrence of the report or informal findings does not constitute official approval of a specific alternative or issue authority to commence design activities.

B. Location Approval. Formal approval of the preferred alternative, traditionally referred to as *location approval*, occurs when the project's environmental clearance document is approved as described in Chapter 3. This also completes the conceptual study phase and advances the project into the design phase and subsequent PS&E preparation.

The description of the preferred alternative contained in the environmental decision making documents, e.g., categorical exclusion, finding of no significant impact, and record of decision, should include preliminary design standards and corridor information to ensure the project will be designed to implement the approved *concept*.

4.6 REPORTING

Conceptual studies provide findings and recommendations that are reviewed and commented on by various agencies and parties. This information can be reported to the agencies in various ways or combined in other documents.

A. Conceptual Engineering Study Reports. The results of the location analysis can be contained in a separate conceptual study report, (e.g., corridor study report) or more commonly be documented in a less formal manner. Memorandums, trip reports, or even semi-formal checklists can be used to record the conceptual study results. In any case, this information should be documented to ensure the findings and/or recommendations, as well as existing conditions, objectives, facts, assumptions, and analyses can be reviewed and understood by all interested and affected parties. All improvement alternatives should be readily supportable from an engineering position, which is contained in these study documents.

If separate formal reports are prepared, they can be in different formats or detail and should be only as formal as appropriate for that scale of project.

B. Environmental Documents. The engineering information and descriptions of the improvement alternatives contained in the environmental documents are summarized from the conceptual studies. Since the final location approval decisions are a product of the environmental process, it is imperative that environmental documents present the engineering data in an accurate, complete, and understandable fashion. The content of environmental documents are described in Chapter 3.

4.7 DIVISION PROCEDURES

Reserved for Federal Lands Highway Division office use in supplementing the policy and guidelines set forth in this chapter with appropriate Division procedures and direction.

CFL Procedures

EFL Procedures

WFL Procedures

<http://www.wfl.fhwa.dot.gov/design/manual/ch04/>